Transverse Echoes in RHIC

Wolfram Fischer

BROOKHAVEN
NATIONAL LABORATORY

RHIC Beam Experiment Workshop
BNL Science Education Center
15 October 2003

- Well known in plasma physics

- Sensitive method to measure diffusion

- Theoretical accelerator papers by Stupakov, Kauffmann (SSC)

- Longitudinal echos observed in
  - FNAL Antiproton Accumulator (Spenzouris, Colestock et al)
  - CERN SPS (Brüning et al)
  - BNL AGS (Kewisch, Brennan)

Wolfram Fischer

- Best produced by
  - Dipole kick, followed by
  - Quadrupole kick (1 turn)
- Quadrupole kick is difficult
  - Use air-core quadrupole from Tevatron (Dejan)
  - Built dedicated power supply
- Echo can also be created by 2 dipole kicks of different strength (F. Ruggiero, SPS)
- Best conditions in RHIC
  - Protons (less IBS than gold)
  - At injection (quad kick more effective)
  - Easy to refill

Wolfram Fischer

BROOKHAVEN
NATIONAL LABORATORY

US-LHC Collaboration Meeting: Accelerator Physics Experiments for Future Hadron Colliders, BNL, 2000
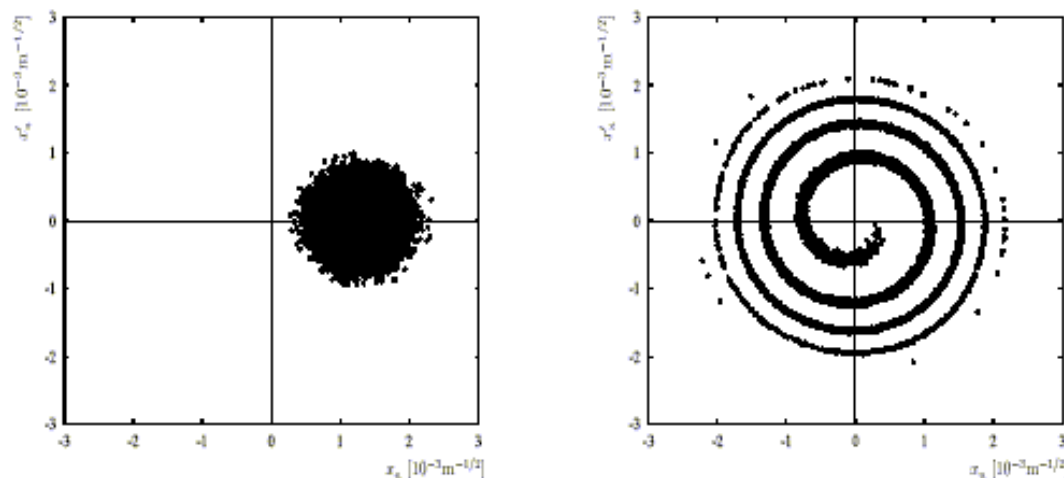

Figure 1: Left: Horizontal particle distribution in normalized phase space after the initial dipole offset. Right: The same distribution 500 turns later.
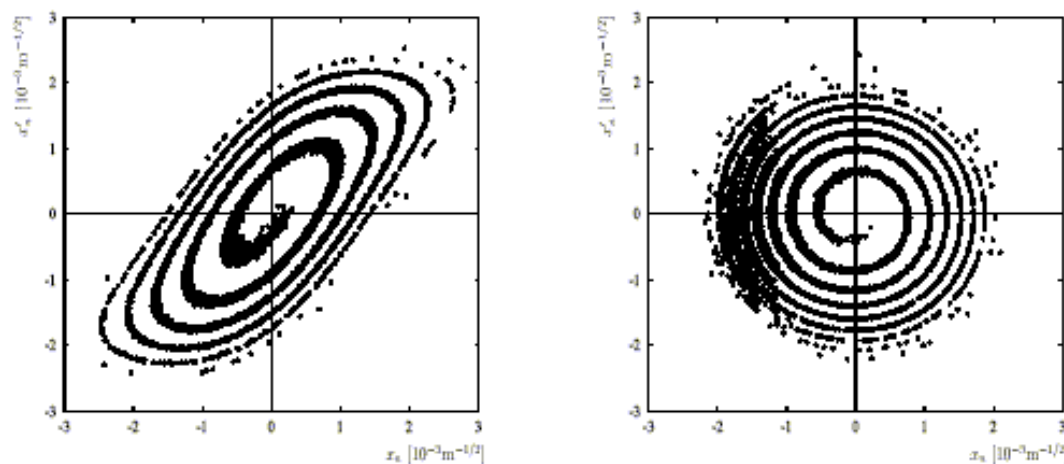

Figure 2: Left: Horizontal particle distribution in normalized phase space right after a 1 turn long quadrupole kick placed 500 turns after the dipole kick. Right: The same distribution 500 turns after the quadrupole kick.
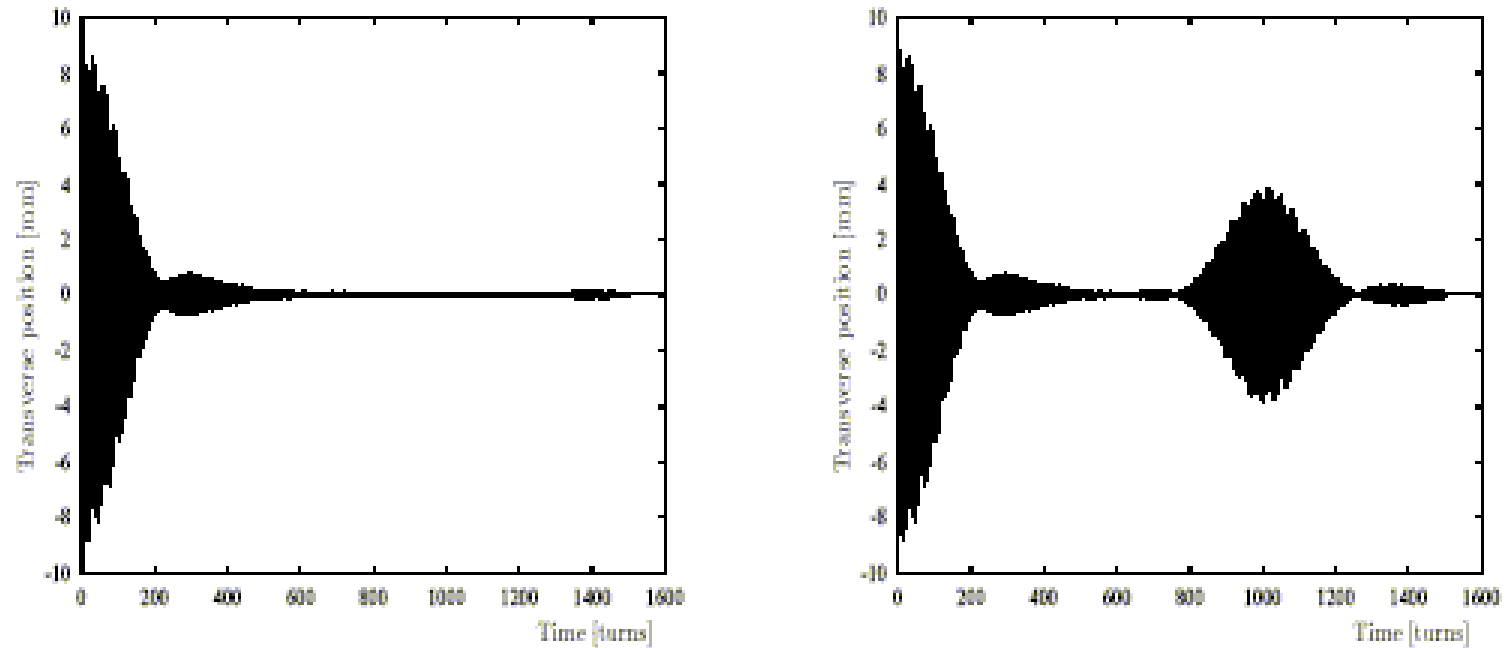
Wolfram Fischer

Figure 3: Left: The dipole moment of the distribution versus time after a dipole kick. Right: The same signal with an additional quadrupole kick at 500 turns after the dipole kick.

[W.Fischer, B. Parker, O. Brüning, "Transverse echos in RHIC", proceedings of the US-LHC Collaboration Meeting: Accelerator Physics Experiments for Future Hadron Colliders, BNL (2000).]

Wolfram Fischer

- Max. echo signal (Stupakov, Handbook)
  one-turn quadrupole kick

$$\eta^{\max} = \frac{aQ}{\tau_d} \frac{\tau}{1 + 8D_0\mu^2\omega_0^2\tau^3/3\varepsilon}$$

- a dipole kick, $Q=\beta/f$ at quad (~0.02 RHIC)
  $\tau_d=T_0/4\pi\mu$, T_0 rev. time, $\omega_0=2\pi/T_0$
  τ time between dipole and quadrupole kick
  μ detuning, D_0 diffusion coefficient
  ε distribution rms

Wolfram Fischer

BROOKHAVEN
NATIONAL LABORATORY

Air core magnet

(Tevatron slow extraction)

l = 1.5 m

B/I = 3.6 T/kA

L = 105 μH

I = 50 A

U = 800 V
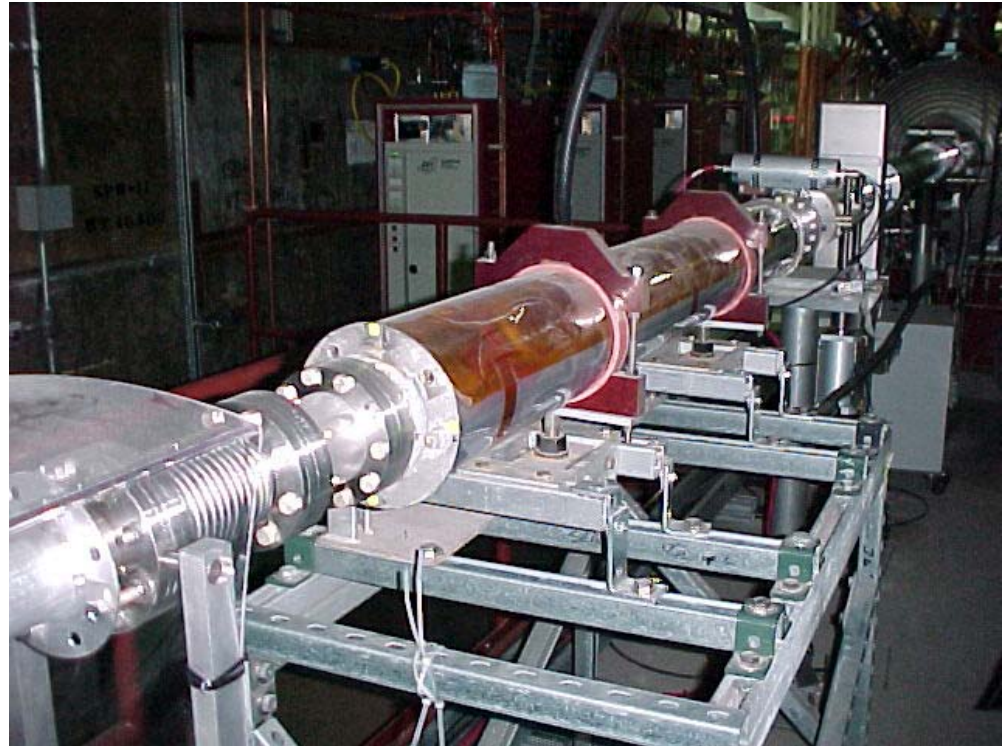
Both parameter sets are for a quadrupole

strength of k = 2E-3/m (f = 500m)

[W. Fischer, A. Jain, D. Trbojevic, "The AC quadrupole in RHIC", BNL RHIC/AP/165 (1999).]

Wolfram Fischer
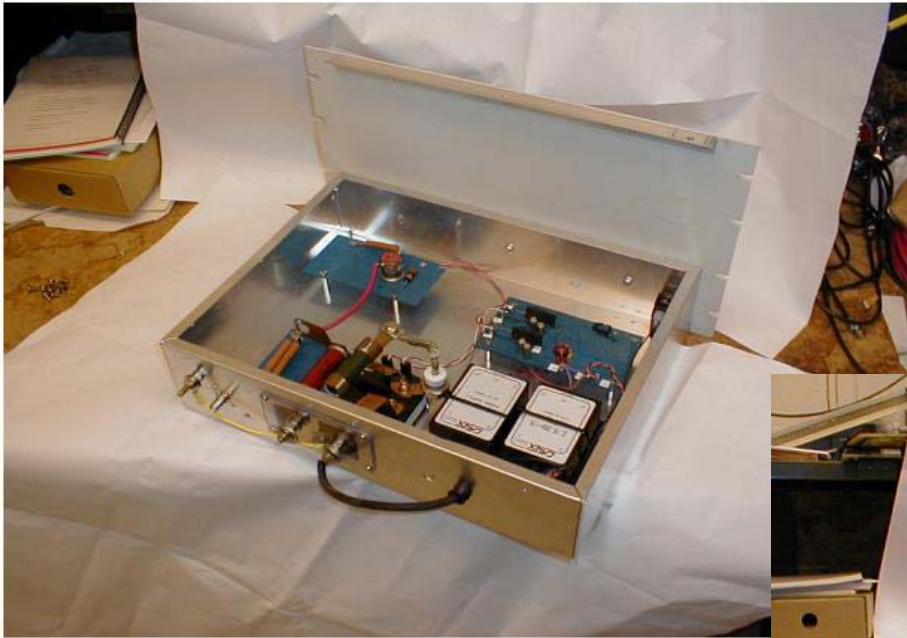
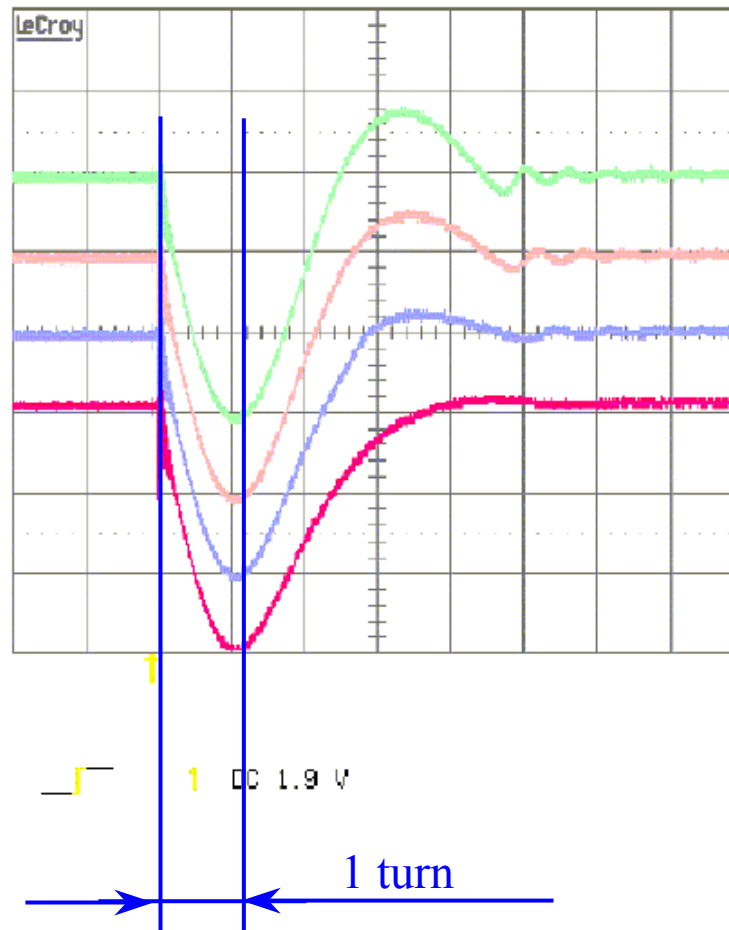J. Addessi, O. Dressler (BESSY), J. Piacentino, D. Warburton

17-Jul-01
10:54:23

TRACE

Trace
OFF   On

SETUP

MULTI ZOOM &
AUTO SCROLL

For Math use
max points
25000000

500 MS/s

NORMAL

LeCroy

10 µs
20.0mV

C:M3
10 µs
20.0mV

B:M1
10 µs
20.0mV

D:M4
10 µs
20.0mV

10 µs

1	5	V	DC
2	20	mV	50Ω
3	50	mV	DC
4	50	mV	DC

1 DC 1.9 V

1 turn

[O. Dressler, "Quadrupole kicker for RHIC", BNL C-A/AP/60 (2001).]

Wolfram Fischer

BROOKHAVEN
NATIONAL LABORATORY

9

- Transverse echo should be observable
  - At injection, single bunch of protons
  - Vertical dipole kick ~4σ (injection kicker)
  - One turn quadrupole kick (k = 2×10^{-3}m^{-1})
  - Signal detection with standard BPMs (million turns = 12 sec)
- Almost all hardware/software is in place
  - End-to-end test not yet done
- If echoes can be observed, transverse diffusion measurements should be possible (IBS, nonlinear dynamics)

Wolfram Fischer